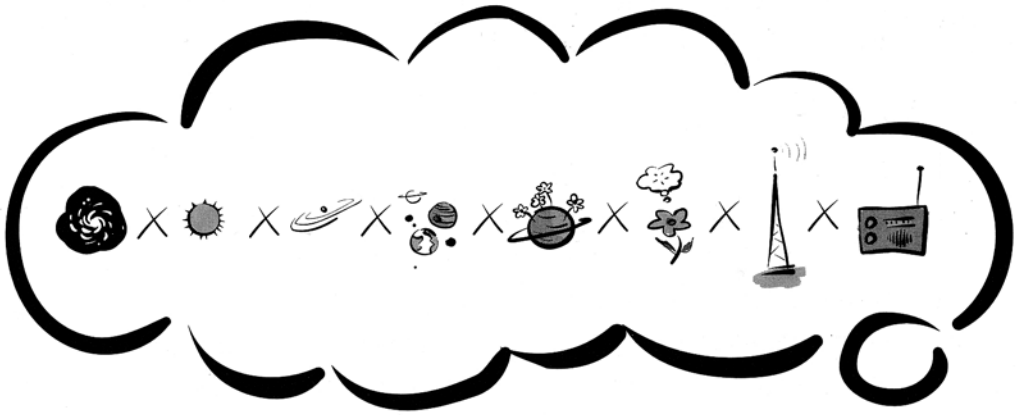
Is there life on other worlds?
Activity Guide

Introduction

Do you think there is intelligent life in our galaxy with which we can communicate? In 1961, Dr. Frank Drake identified eight terms to help people think about what would have to take place for such communication to be possible.

See what you think the chances are by making your own estimate for each of the terms below. The conservative and optimistic values indicate the range of opinion among scientists with regard to each term. You can use the conservative or optimistic estimates or use another value, depending on your own intuition.



What to Do

To estimate the number of worlds in the Milky Way galaxy that have intelligent life that we can detect using radio technology, follow these steps:

1. **Make estimates for each of the eight terms listed on the Using the Drake Equation worksheet.**
2. **Convert percentages to decimals before multiplying.**
3. **Multiply the estimates you made for the eight terms.**

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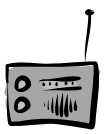
Using the Drake Equation

Name _____

Date _____

	TERM	BACKGROUND	CONSERVATIVE ESTIMATE	OPTIMISTIC ESTIMATE	YOUR ESTIMATE
	**1** The total number of stars in the Milky Way galaxy	These numbers are based on observations of the stars in our galaxy, the Milky Way galaxy, and of other galaxies we believe to be like our own. Most scientists believe the number of stars to be 400 billion.	**100 billion**	**600 billion**	
	**2** The percentage of stars that are appropriate	Many scientists believe that a appropriate star has to be like our sun, which is a Main Sequence, G-type star. Only about 5% of the stars in our galaxy are G-type stars, though about 10% are the closely related F- and K-type stars. About 50% of stars exist in binary or multiple systems, which many scientists feel make them inappropriate.	**5%**	**15–45%**	
	**3** The percentage of these appropriate stars that have planetary systems	Appropriate stars may not have planets circling them. We have only just begun detecting extra-solar planets, so we don't really know how common they are.	**5%**	**50–100%**	
	**4** The average number of habitable planets or moons within a solar system	Our only example of this term is our own solar system. Could Earth be the only habitable place in our solar system? Is our system typical? Remember that if one system has no habitable planets or moons and another has four, the average would be two per system.	**0.1** On average, there is one habitable planet in every ten systems	**4** On average, there are four habitable planets in every system	
	**5** The percentage of habitable planets or moons that develop life	Having a planet or moon that is appropriate for life doesn't necessarily mean that life will arise. No real data are available to help us estimate this term. Earth is the only planet on which we know there is life. However, bacterial life existed on Earth shortly (geologically speaking) after its formation, possibly indicating that the development of life is easy. Many scientists believe that whether or not life arises depends on many factors.	**0.000001%** Life is a rare accident that is unlikely to happen elsewhere	**100%** Life will arise if conditions are appropriate	
	**6** The percentage of planets with life that develop intelligence	On Earth, humans developed intelligence, apparently as an evolutionary advantage. However, this term depends on how you define intelligence. Are dolphins, gorillas, octopuses, and ants intelligent? Furthermore, single-celled life existed on Earth very early, and multicellular life took 2.5 billion years to form (a very long time, geologically speaking). Maybe the development of complex life, let alone intelligent life, is unusual.	**0.0001% or less** Only one in a million planets with life will develop intelligence	**100%** Any planet with life will develop intelligence	
	**7** The percentage of intelligent life that develop radio technology	Communication with intelligent extraterrestrials requires that we hear from them. Given the vast distances of space, they would probably send signals which travel at the speed of light, such as radio waves. On Earth, humans have only just developed radio technology, so possibly this term should have a low value. But, we did eventually develop radio technology, so maybe this is true of all intelligent beings.	**0.0001% or less** Only one in a million planets with intelligent civilizations will develop radio technology	**100%** All intelligent life will develop radio technology	
	**8** The percentage of "current" civilizations having radio technologies	Will an extraterrestrial's signals overlap with the lifespan of the receiving civilization? Extraterrestrials that sent signals a million years ago from a world a million light years away would still overlap with us, even if they died out long ago. So, how long do civilizations with radio technology last? A high level of technological development could bring with it conditions that ultimately threaten the species. Or maybe, once a society has radio technology, it may survive for a long time. Finally, radio signals may give way to more advanced, less noisy technologies such as optical fiber. No one would hear us then!	**0.0001% or less** One in a million civilizations with radio technology will develop it in time to detect signals from another civilization	**10%** One in a ten civilizations with radio technology will develop it in time to detect signals from another civilization	

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Think About It

Name _____

Date _____

1 **To find out your estimate of the number of worlds in the Milky Way galaxy that have intelligent life that we can detect using radio technology, fill out the Drake Equation worksheet and multiply the eight terms together. Write your answer here:**

2 **Based on your estimates, how good are our chances of hearing from intelligent extraterrestrials?**

3 **How does your answer to Question 2 compare to what you thought before you began the activity?**

4 **Can your answer to Question 1 be less than one? Why or why not?**

5 **When making estimates, in which terms did you have the most confidence? The least? Why?**

6 **Are you more optimistic or conservative when it comes to thinking about extraterrestrial life with radio technology in the Milky Way galaxy? Why?**

7 **How could you adjust the estimates in the equation to have it come out so that Earth is the only planet in the Milky Way galaxy with radio technology?**

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8 **If tomorrow's newspaper headline read, "Message Received from Outer Space," what would it mean to you?**

9 **What would your reaction be if we discovered microbes on another planet? Plants? Insects? Mammals? Intelligent life?**

10 **If microbial life were discovered on another planet, what implications might such a discovery have?**

11 **How would you define extraterrestrial now? How does your current definition differ from the one that the class developed earlier in the activity?**

12 **What do you think is the most abundant life form on Earth?**

13 **If life exists elsewhere, what do you think it will look like?**

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Teacher Answer Guide to the *Think About It* Questions

These background notes provide answers to some of the questions on the Student Activity Guide and can be used to help guide a class discussion based on those questions. Questions 2, 3, 7, 8, 9, and 11 ask students to reflect on their own feelings, perceptions, or idea, and therefore have no background notes.

1 Based on the eight terms, what is your estimate?

While Terms 5 to 8 are percentages, the final number that students obtain is a discrete number rather than a percentage or a probability. This number represents a student's estimate of the number of civilizations with radio technology that we can detect.

4 Can your answer to Question 1 be less than one?

While there is no right answer, there are wrong answers. Because Earth exists, the final answer cannot be zero and probably should not be less than one. If students choose low probabilities for Terms 5 to 8, they may need more than the 400 billion stars in the Milky Way galaxy to obtain a final answer of one. This would require considering additional galaxies to account for the existence of Earth.

5 In which terms did you have the most or least confidence?

Estimating numbers for the eight terms becomes increasingly a matter of conjecture as one goes from Term 1 to Term 8. There is widespread agreement only for the first two terms.

6 Are you more optimistic or conservative?

An answer of one states that Earth is the only place with intelligent life that has radio technology. There may still be life or even intelligent extraterrestrials out there, but we cannot communicate with them because they do not have radio technology. Any number larger than one implies that we may receive signals from intelligent extraterrestrials someday. However, make the distinction between detection and communication, which is a two-way exchange. With a small final number, actual communication is less likely. With a large final number, actual communication becomes increasingly likely.

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10 What are the implications of discovering microbial life?

Many students express disinterest in discovering anything less than a bona fide, Hollywood-style extraterrestrial. However, no life beyond Earth has ever been found, which implies that life may be a rare accident that happened on Earth due to an extraordinary convergence of circumstances and that it is unlikely to happen elsewhere. In this context, discovering microbial life would help us understand more about how life arises and what conditions it can tolerate. Furthermore, it would help answer the question of whether life is a common process in the universe. In short, discovering microbial life beyond Earth would be a profound discovery. By multiplying Terms 1 to 5, students can make their own estimate of how many worlds in our galaxy have life of any sort.

12 What is the most abundant life form on Earth?

We live in the age of bacteria. For the past three and a half billion years, bacteria have been the dominant life form in terms of numbers and biomass. They are key to many biological, geological, and chemical processes, and many scientists think that multicellular organisms became possible only after single-celled bacteria began living symbiotically within a cell membrane.

13 If life exists elsewhere, what do you think it will look like?

Astrobiologists feel that most extraterrestrial life will be bacteria-like, living beneath a planet's or moon's surface and using chemical energy for their needs. Animal life, and especially intelligent animal life, is probably much rarer.